R842-09 ERIC REPORT RESUME

ED 010 204 1-31-67 24 (REV)

THE ATTAINMENT OF CONCEPTS FROM FIGURAL AND VERBAL INSTANCES, BY INDIVIDUALS AND PAIRS.

RAMSAY, JAMES G. * KLAUSMEIER, HERBERT J.

XY081702 UNIV. OF WIS., MADISON CAMP. RES. AND DEV. CTR.
CRP-2850-TR-4
BR-5-0216-TR-4
TR-4
- -65
EDRS PRICE MF-$0.09 HC-$0.88 22P.

*CONCEPT FORMATION, LEARNING PROCESSES, CONCEPT TEACHING, FUNDAMENTAL CONCEPTS, *PERFORMANCE, TASK PERFORMANCE, PERFORMANCE FACTORS, GROUP ACTIVITIES, INDIVIDUAL ACTIVITIES, *VERBAL LEARNING, *STIMULUS BEHAVIOR, COLLEGE STUDENTS, *RESEARCH AND DEVELOPMENT CENTERS, COGNITIVE PROCESSES, MADISON, WISCONSIN

AN ATTEMPT WAS MADE TO CLARIFY RELATIONSHIPS BETWEEN TWO VARIABLES TAKEN FROM TWO MAJOR CLASSES--A VARIABLE RELATED TO CONDITIONS OF LEARNING AND A STIMULUS VARIABLE. SPECIFICALLY, THE STUDY DEALT WITH CONCEPT ATTAINMENT BY INDIVIDUALS AND IDENTIFIED THROUGH FIGURAL OR VERBAL INSTANCES. PERFORMANCE WAS ASSESSED WITH FIVE DEPENDENT VARIABLES--TIME TO CRITERION, TOTAL NUMBER OF CARD CHOICES, NUMBER OF CARD CHOICES TO THE FIRST HYPOTHESIS, NUMBER OF HYPOTHESES OFFERED, AND NUMBER OF ATTRIBUTES CHECKED TO THE FIRST HYPOTHESIS. IT WAS FOUND THAT PAIRS WERE IN GENERAL EQUAL OR SUPERIOR TO INDIVIDUALS IN ATTAINING CONCEPTS. SUBJECTS USING FIGURAL MATERIAL WERE EQUAL TO OR BETTER THAN THOSE USING VERBAL MATERIAL IN ATTAINING CONCEPTS. WHEN ORDINAL POSITION OF THE CONCEPT IN THE SEQUENCE WAS PLOTTED AGAINST THREE DEPENDENT VARIABLES, IT WAS FOUND THAT PERFORMANCE WAS POOREST ON THE FIRST CONCEPT, THAT IT IMPROVED MARKEDLY ON THE SECOND, AND THAT IMPROVEMENT CONTINUED FOR THE THIRD AND FOURTH CONCEPT, BUT AT A SLOWER RATE. PROBLEM SEQUENCES LED TO DIFFERENCES IN PERFORMANCE AS MEASURED BY TIME TO CRITERION AND NUMBER OF HYPOTHESES OFFERED. ALTERNATIVE EXPLANATIONS ARE SUGGESTED TO ACCOUNT FOR THE RESULTS. (JC)

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

Technical Report No. 4

THE ATTAINMENT OF CONCEPTS FROM FIGURAL AND VERBAL INSTANCES BY INDIVIDUALS AND PAIRS

by James G. Ramsay

Based on a master's thesis
under the direction of

Herbert J. Klausmeier

ED010204

Research and Development Center
for Learning and Re-Education
University of Wisconsin
Madison, Wisconsin
1965

The research and development reported herein was performed pursuant to contracts with the United States Office of Education, Department of Health, Education, and Welfare, under the provisions of the Cooperative Research Program

Center No. C-03 / Contract OE 5-10-154

CRP No. 2850

POLICY BOARD OF THE CENTER

Max R. Goodson, Professor of Educational Policy Studies
Co-Director, Administration

Herbert J. Klausmeier, Professor of Educational Psychology
Co-Director, Research

Lee S. Dreyfus, Professor of Speech and Radio-TV Education
Coordinator of Television Activities

John Guy Fowlkes, Professor of Educational Administration
Advisor on Local School Relationships

Chester W. Harris, Professor and Chairman of Educational Psychology
Associate Director, Research

Burton W. Kreitlow, Professor of Agricultural and Extension Education
Coordinator of Adult Basic Education Activities

ED010093

Julian C. Stanley, Professor of Educational Psychology
(on leave September 1, 1965 - August 31, 1966)

Lindley J. Stiles, Dean of the School of Education
Advisor on Policy

Henry Van Engen, Professor of Mathematics and Curriculum & Instruction
Associate Director, Development

PREFACE

This technical report is based on the master's thesis of James Ramsay. Thesis committee members were Herbert J. Klausmeier, Chairman; Chester W. Harris; and Thomas Johnson.

In our program of research and development at the Center for Learning and Re-education, we have identified four main classes of manipulable variables; those related to stimulus material, those related to instructions used in the experiment, those related to response modes, and those related to conditions of learning. The members of a fifth class, termed organismic variables, are used primarily to stratify samples of subject. We have organized these classes into a taxonomy of variables which is outlined in Technical Report No. 1 of the Center.

Mr. Ramsay's study is an attempt to clarify relationships among two variables taken from two of the major classes—a variable related to conditions of learning and a stimulus variable. Specifically, the study dealt with concept attainment by individuals and pairs where the concepts were identified through figural or verbal instances.

A major conclusion of this study is that pairs attain concepts more efficiently than do individuals. Caution is needed in interpreting and applying this conclusion. Pairs in the present study, and in most other laboratory studies, perform better initially than individuals. Although this is true, one should not generalize to non-laboratory situations without further study in the non-laboratory setting. Would this superior initial performance by pairs have continued when working individually on later similar tasks? This question was not studied by Mr. Ramsay. Other research indicates that those who work individually, though performing less well initially than pairs, perform better subsequently than do the members of pairs.

Herbert J. Klausmeier
Co-Director for Research

PRECEDING PAGE BLANK-NOT FILMED

CONTENTS

		PAGE
	List of Tables and Figures	vii
	Abstract	ix
I.	Problem	1
II.	Method	2
	Subjects	2
	Experimental Materials	2
	Experimental Procedure	3
	Experimental Design	4
	Independent Variables	4
	Distribution of Subjects	4
	Treatment of the Data	4
	Dependent Variables	4
	Statistical Analysis	5
III.	Results	6
	Time to Criterion	6
	Total Number of Card Choices	7
	Number of Card Choices to the First Hypothesis	8
	Number of Hypotheses Offered	8
	Number of Attributes Checked to the First Hypothesis	10
IV.	Discussion	11
	References	13

PRECEDING PAGE BLANK NOT FILMED

LIST OF TABLES AND FIGURES

PAGE

Table 1. Hypothetical Sequence of Card Choices to Illustrate Dependent Variables 4

Table 2. Summary of Analysis of Variance with Time to Criterion as the Dependent Variable 6

Table 3. Mean Times Which Were Significantly Different with Time to Criterion as the Dependent Variable 7

Table 4. Summary of Analysis of Variance with Total Number of Card Choices as Dependent Variable 8

Table 5. Summary of Analysis of Variance with Card Choices to the First Hypothesis as the Dependent Variable 9

Table 6. Summary of Analysis of Variance with Number of Hypotheses Offered as the Dependent Variable. 9

Table 7. Summary of Analysis of Variance with Number of Attributes Checked to the First Hypothesis as Dependent Variable. 10

Table 8. Means of Groups Involved in the Significant Interaction of Size of Group with Type of Material Where Number of Attributes Checked to the First Hypothesis Was Dependent Variable . . . 10

Figure 1. Time to Criterion as a Function of Ordinal Position of the Concept 7

Figure 2. Number of Hypotheses Offered as a Function of Ordinal Position of the Concept 9

Figure 3. Number of Attributes Checked to First Hypothesis as a Function of Ordinal Position of the Concept 10

PRECEDING PAGE BLANK-NOT FILMED

ABSTRACT

In this study, the performance of individuals and pairs attaining four concepts was compared; the effects of two types of material were determined; and the effects of four sequences of presentation of the concepts were determined. Performance was assessed with five dependent variables: time to criterion, total number of card choices, number of card choices to the first hypothesis, number of hypotheses offered, and number of attributes checked to the first hypothesis.

It was found that pairs were in general equal or superior to individuals in attaining concepts. A tentative explanation for this finding was that pairs were better able to gather information because the members of the pairs had, between them, a superior joint memory capacity.

Ss using figural material were equal to or better than Ss using verbal material in attaining concepts. It was suggested that information was more readily obtainable on the figural board than on the verbal board.

When ordinal position of the concept in the sequence was plotted against three dependent variables, it was found that performance was poorest on the first concept, that it improved markedly on the second concept, and that improvement continued for the third and fourth concepts, but at a slower rate. It was suggested that this improvement was due to familiarization of the Ss with the material and practice on the task.

The four different sequences in which the problems were presented led to statistically significant differences in performance as measured by time to criterion and number of hypotheses offered. Several alternative explanations were suggested to account for these results.

I
PROBLEM

The discovery of consistent experimental results in the field of human problem solving is, at best, an elusive business. The scope of this field is constantly expanding and shows no indications of slacking off. If anything, the trend is an inverted pyramid with one finding begetting several new problems. It is, perhaps, for this reason that the study of problem solving has become a superclass, under which are subsumed a number of more specialized categories. One such area which is itself expanding rapidly is the study of concept attainment. Even in such a specific area, however, findings are as often contradictory as they are compatible. In studies where the effect of type of material on concept attainment is tested, these kinds of contradictory findings are exhibited. For example, Davidon (1952) found that concepts were more easily attained when pictures of objects were employed than when the written names of the objects were used. Runquist and Hutt (1961) found the opposite to be true. Heidbreder's classic finding (1946) was that concrete objects were more easily classified into concepts than were abstract forms. Bruner et al. (1956) found that college students could attain concepts more efficiently with abstract material than with drawings of pairs of persons.

Where the performance of groups on problem solving tasks is compared with that of individuals, findings are also ambiguous. Duncan (1959), in a comprehensive review of the literature, concluded that individuals were superior to groups in problem solving. Several studies (Tuckman and Lorge, 1962; Restle and Davis, 1962), however, have found groups to be superior to individuals. Klausmeier, Wiersma, and Harris (1963) found groups more efficient than individuals on an initial set of concept attainment problems, while individuals who participated initially as individuals were more efficient on a transfer set of problems than were individuals who learned initially in groups.

Further study on type of material and group size would thus appear to be necessary in order to determine the effects of these variables on concept attainment.

The purposes of the present study were:

1. To compare the performances of pairs and individuals on a concept attainment task; and
2. To determine the effects of two types of material, figural and verbal, on concept attainment behavior.

II
METHOD

The method of using a multidimensional stimulus array from which Ss choose instances to compare with a focus card and are then informed whether their choice is a positive or negative instance, was first fully described by Bruner et al. in their work on concept attainment. These authors were able to deal with many aspects of concept attainment including the effects of complexity and cognitive strain; the method also allowed them to develop a system of strategy identification in concept attainment and to deal with strategies in detail. The Bruner et al. method was used as a model for the present study because of its flexibility; by using this method, three main effects and their interactions were studied. These effects were assessed by five dependent variables.

SUBJECTS

The subjects were 96 students from an introductory course in educational psychology at the University of Wisconsin. The age range of the Ss was from 19 to 26; the modal age was 21. Sixty-four females and 32 males participated in the experiment.

EXPERIMENTAL MATERIALS

Two types of stimulus arrays were used in the experiment. One of the arrays consisted of 64 randomly arranged 3 × 3 in. cards, each of which displayed one of two values for each of six attributes. The attributes and their corresponding values were:

number of borders - one or two
continuity of borders - solid or broken
number of figures - one or two
size of figures - large or small
color of figures - red or green
shape of figures - circle or ellipse

Each card contained a unique combination of attribute values printed on it, and could be completely described in terms of its number of borders, continuity of borders, number of figures, size of figures, color of figures and shape of figures. The attribute values printed on the cards were figural in nature. That is, a card on the figural board actually contained borders and figures. The cards were arranged in eight rows and eight columns. Below each card was a two digit identification number which was also randomly determined. This array was termed the Random Figural (RF) array.

The second array displayed exactly the same information as the RF board, but the information was contained in words. The cards on this board contained the same combinations of attribute values as the RF array. The cards were arranged in the same position on the board and were given the same identification numbers. But, where the cards on the RF array displayed actual borders and figures, the cards on the second array displayed printed words which represented the figural material. This display was termed the Random Verbal (RV) board.

Four concepts, each with two relevant attributes, were to be attained by the Ss. A concept may be considered as a particular attribute value or combination of attribute values which define a subset of cards on the display. For example, "all cards with green, circular figures" would be a concept which defines a subset of cards on the display. Each positive instance of this concept would display green circles. For a concept consisting of two relevant attributes there are 16 cards on the display which are exemplars or positive instances of the concept and 48 cards which are non-exemplars or negative instances of the concept. There were four concepts to be attained by all individuals and pairs. Since the four concepts were arranged in four sequences, in a Latin square, each concept was designated by a letter. The concepts were:

A. Two Borders, Green figures
B. Broken Borders, Elliptical figures
C. Two, Circular figures
D. Small, Red figures

The same concepts were attained on the RF and RV boards.

EXPERIMENTAL PROCEDURE

Each individual or pair was tested separately. The Ss selected for the experiment participated as part of a course requirement. They listed their free hours and were scheduled in one of those hours. Preceding the experiment the Ss were informed that they would take part in a concept attainment experiment. After participating, Ss were requested not to divulge the nature of the experiment to their classmates.

Upon reporting to the learning laboratory, each individual or pair was seated at a table across from E. The array of cards, RF or RV, was laid horizontally on the table in front of the Ss. The following instructions were read by E:

> This experiment is concerned with how people attain concepts. You are going to have an opportunity to work several exercises in concept attainment. Your performance on this is not related to your course grade.
>
> Here is a display of 64 cards. Each card contains six attributes. The attributes are number of borders, type of borders, number of figures, size of figures, color of figures, and shape of figures. Each card has either one or two borders, broken or solid borders, one or two figures, large or small figures, red or green figures, and circular or elliptical figures. (E demonstrates with slip of paper which has the attributes listed in one column and the defining characteristics in another column.)
>
> Every card on the board is different from every other card in at least one of the six attributes just described. However, there are a number of ways certain cards may be grouped so that all cards in a specific group possess one or more of the same attributes. To illustrate from the animal kingdom, we know that all animals can be classified into two distinct groups—vertebrate and invertebrate. Thus, every animal either does or does not have a backbone and may be put into either group—vertebrate or invertebrate. In a like manner, all the cards indicative of "Green Circular Figures" may be grouped together to form the concept "Green Circular Figures." Here are two of several cards which belong to this concept. (E points to #72 and #35.) You pick out three others which also belong to the "Green Circular Figures" concept. (Wait for S to pick out such cards.) Now pick out two cards which do not belong to this concept. (Wait for S to pick two such cards.) O.K., that's fine. This is an example of a concept that has two relevant attributes, the two relevant attributes being color and shape of figures. (E, in putting down this concept, puts a check in (X) green and (X) circle on slip.)
>
> In this experiment your job is to attain the concept that I have selected. At the beginning of each task I shall show you one card which belongs to a concept that I have selected and which you are to attain. This card we will call the focus card. You are to select cards which you want to test as belonging to the same concept as the focus card. Select each of your successive cards by pointing to it and reading off the number which is immediately below it. After each selection I shall state "yes" or "no" depending upon whether or not the card you selected belongs to the concept. As you find which cards do and do not belong to the concept you can ascertain the concept.
>
> Whenever you think you know the concept, stop and ask for a slip of paper. Then check the concept on the slip, and I will read the concept back to you so there is no misunderstanding. If your concept is correct the task is completed. If not, I'll simply say "not correct" and you will continue selecting cards until you again think you know the concept. You may present as many concepts as you like. The job is to attain the concept as quickly as possible. Are there any questions?

In addition to these instructions, the pairs were told that they were to work as a team, that they were to cooperate, and that they could talk freely during the course of the experiment.

Each individual or pair was then given the four concepts, one at a time, on one of the boards. A task was initiated when E indicated a focus card or initial positive instance of the concept. Ss then proceeded to choose instances; E said "yes" to those instances which belonged to the concept and "no" to those instances which did not belong to the concept. When the Ss thought that they had attained the concept,

they offered an hypothesis. Slips of paper were supplied for this purpose. These slips listed the attributes and their corresponding values. Ss offered an hypothesis by checking with a pencil those values which they thought made up the concept and handing the checked slip to E. E read back the hypothesis to the Ss in order to confirm the Ss' hypotheses and to prevent mechanical errors on the part of the Ss. This procedure was followed for each of the four problems.

If an individual or pair was unable to attain the first concept in 20 minutes or the second concept in 15 minutes, the data were not used and another individual or pair was run as a replacement. Five individuals and four pairs who did not meet these criteria were replaced. During the experimental sessions, E recorded Ss' card choices, the hypotheses offered, and the time taken to attain the concept.

EXPERIMENTAL DESIGN

Independent Variables

Size of group, type of material, and sequence were treated as independent variables. The phrase "size of group" when here used does not imply that the findings of this study are necessarily applicable to groups with more than two members; it is simply a label to identify an independent variable with individuals and pairs being two levels of this variable. There were two types of material used in this study, figural and verbal. Four concepts, each with two relevant attributes, were worked by each S or pair. The concepts were labeled A, B, C, and D. The concepts were arranged into four sequences which formed a Latin square. The four sequences labeled 1, 2, 3, and 4 were:

1. D A B C
2. C B A D
3. A D C B
4. B C D A

Although sequence was treated as an independent variable in the statistical analyses of the data, the effects of the four sequences were not of primary interest in this study. The four sequences were incorporated as a counterbalancing device.

Distribution of Subjects

Samples of 64 females and 32 males were randomly chosen from an introductory course in educational psychology. These Ss were naive with respect to the concept attainment task they were to perform. Ss were assigned randomly to 16 treatment groups with the restriction that there were to be equal proportions of male and female pairs and of male and female individuals in the treatment groups. Each treatment group consisted of pairs or individuals working on figural or verbal material with concepts arranged in one of four sequences.

TREATMENT OF THE DATA

Dependent Variables

Five dependent variables were used to assess performance of Ss on the concept attainment task: time to criterion, total number of card choices, card choices to the first hypothesis, number of hypotheses offered, and number of attributes checked to the first hypothesis. These measures can best be demonstrated by example. A sample data sheet is given in Table 1. The value of each of the six attributes is represented by either a zero or a one.

TABLE 1

Hypothetical Sequence of Card Choices to Illustrate Dependent Variables

Ss Card Choices	Description	Type of Instance
07 (focus)	000000	+
17	100000	+
36	001000	+
04	110000	-
Hypothesis offered	-0----	Incorrect
19	010010	-
16	101000	+
18	000001	+
Hypothesis offered	-0-0--	Correct
	Time 107 Sec.	

Time to criterion was defined as the time it took the Ss to attain the concept. A concept was considered to be attained when a correct hypothesis was offered. In the example given

in Table 1, time to criterion was 107 seconds. Total number of card choices was six in the example. There were three cards chosen before the first hypothesis was offered. A total of two hypotheses were offered.

Number of attributes checked is an estimate of the information Ss had access to concerning the relevance of attributes to the concept. Again the example in Table 1 should be considered. On learning card 17 was positive, it could be determined that the first attribute was irrelevant. It is only an inference that the Ss actually assimilated this information. On learning card 36 was positive, it could be determined that the third attribute was irrelevant to the concept.

On learning card 04 was a negative instance, it could be determined that the second attribute was relevant; that is, that the value of that attribute on the focus card was relevant to the concept. In this case, two attributes have been varied from the focus card, but since the first attribute was found to be irrelevant, varying that attribute is of no consequence in further card choices. At this point in the sequence of card choices an hypothesis was offered which was incorrect. A score of 3 would be given for the number of attributes checked to the first hypothesis.

It should be re-emphasized that number of attributes checked requires an inference, the inference being that Ss used the information which was available to them. There is surely some inaccuracy in this measure. Though the information was available it may not have been noticed, or it may have been noticed and then forgotten.

It should also be mentioned that card choices to the first hypothesis is to some degree positively correlated with total number of card choices. Each time a concept was attained on the first hypothesis, the correlation between these measures of performance on that concept was 1.00.

Statistical Analysis

An individual or pair attained four concepts. Scores on these concepts, as measured with a particular dependent variable, were summed and treated as one score. Thus, 64 scores were involved in each analysis of variance (ANOVA). Five such analyses of variance were computed, one for each dependent variable. Each analysis was a three-way ANOVA with fixed effects, where the mean squares for three main effects, three first order interactions, and the second order interaction were each divided by the mean square for Ss within groups in order to obtain F ratios. The probability of a Type I error was set at .05; effects which reached the .01 level of significance were indicated.

III

RESULTS

Results will be presented separately for the ANOVA computed for each dependent variable. These results will include a summary table of the ANOVA and means of groups for which significant differences were obtained.

Time to Criterion

The summary of the ANOVA with time to criterion as the dependent variable is presented in Table 2. Type of material was shown to be significant at the .01 level and sequence at the .05 level. Neither size of group nor any of the interactions were significant. The means of groups for which significant F ratios were obtained are presented in Table 3. As can be observed from this table, Ss who attained concepts on the RV board took, on the average, about 8.55 minutes more to attain the concepts than did the Ss on the RF board.

A possible explanation for this highly significant effect is that the information from the figural instances was more readily observable than was the information from the verbal material. It would seem relatively easy for Ss to determine which attribute values appear on a figural instance, once they had directed their attention to the instance. For example, Ss could glance at any part of the border on an instance and determine whether the entire border was broken or solid. Ss using the verbal material would have to read the words printed on a card in order to determine the attribute values on that instance. Obtaining information, encoding and storing this information, would all seem to be more complicated for Ss using verbal material. These problems in dealing with information on the verbal material may have resulted in Ss taking more time to consider each instance on the RV board. This increase in time would take place for all those cards which Ss examined and then rejected as well as for those cards which were finally selected. Thus, the search behavior of the Ss using verbal material

TABLE 2

Summary of Analysis of Variance with Time to Criterion as the Dependent Variable

Source	SS	df	MS	F
A. Size of group	86,656.64	1	86,656.64	1.32
B. Type of Material	1,052,419.52	1	1,052,419.52	16.02**
C. Sequence	808,968.39	3	259,656.13	4.10*
A × B	877.64	1	877.64	< 1
A × C	469,025.01	3	156,341.67	2.38
B × C	56,800.39	3	18,933.46	< 1
A × B × C	283,612.52	3	94,537.51	1.44
Ss/Groups	3,153,080.75	48	65,689.18	
Total	5,911,440.86	63		

**p < .01
*p < .05

TABLE 3

Mean Times Which Were Significantly Different with Time to Criterion as the Dependent Variable

Significant Effect	Group	Mean Times (in sec.)
Type of Material	Figural	969.12
	Verbal	1482.06
Sequence	1	1297.25
	2	1034.50
	3	1562.31
	4	1008.31

would appear to have taken longer, resulting in a longer time to criterion.

Sequence was also a significant factor. It can be observed from Table 3 that Ss attaining concepts in sequences 1 and 3 took longer than Ss attaining concepts in sequences 2 and 4. The four concepts to be attained were:

A. Two Borders, Green figures
B. Broken Borders, Elliptical figures
C. Two, Circular figures
D. Small, Red figures

and the four sequences of concepts arranged in a Latin square were:

1. D A B C
2. C B A D
3. A D C B
4. B C D A

The significant sequence effect implies that the order in which particular concepts were presented affected performance of Ss on those concepts. It is very difficult to account for this, because this experiment was not designed to study differences between sequences and concequently not all possible sequences were used. The only reason sequences were designed was to counterbalance the order of presentation of the concepts. It was not expected that there would be any differences between sequences, and any final explanation of these differences must await further experimentation specifically designed to deal with this problem. One may, however, speculate on possible explanations. It may be that the significance of the sequence effect is accounted for entirely by sequence 3 which, for some reason, resulted in a higher mean time to criterion than the other three sequences. Another possibility is that concepts B and C facilitated performance on concepts A and D to a relatively greater degree than concepts A and D facilitated performance on concepts B and C. That is, sequences 2 and 4 where concepts B and C were first may have resulted in lower mean times to criterion because there was relatively greater positive transfer from the first two to the last two concepts in sequences 2 and 4 than in 1 and 3.

These possible explanations stop short of answering the question of "why?" Just why sequence 3 was associated with longer times to criterion or why greater positive transfer may have occurred must remain unknown.

It is interesting to observe how performance improved from the first to the fourth concept. The mean times to criterion for the four ordinal positions are plotted in Figure 1. The resulting progression of points is one which is frequently obtained in learning experiments where time to criterion is plotted over a series of trials. At first there is a sharp decrease between the first and second ordinal positions in time taken to attain the concept. Decreases continue between the second and third and the third and fourth positions, but for each successive pair of concepts to be attained the decrement in time is less. The changes in time taken to attain the concepts probably reflect the Ss' familiarization with the materials, practice on the task, and the development of systematic procedures to gather information.

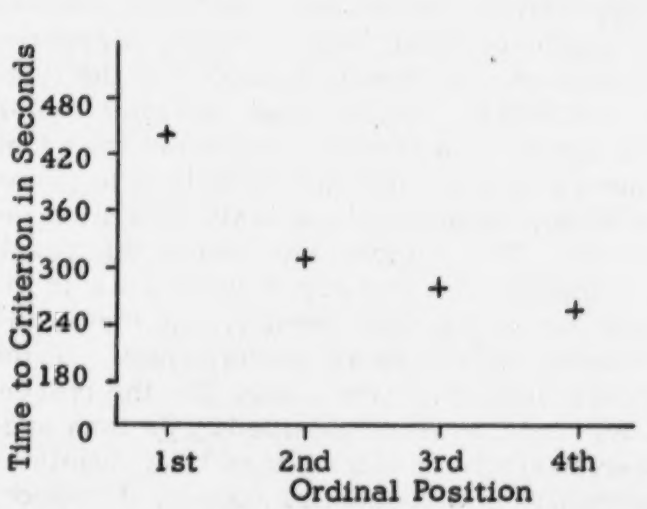

Fig. 1. Time to Criterion as a Function of Ordinal Position of the Concept.

Total Number of Card Choices

The summary of the ANOVA with total number of card choices as the dependent variable is presented in Table 4. The main effect of size of group was shown to be significant at the .01 level with the mean number of card choices for individuals exceeding that of pairs. The other main effects and interactions were not significant. Pairs, on the average, made 50.94 total card choices; individuals, 71.44. Three rea-

TABLE 4

Summary of Analysis of Variance with Total Number of Card Choices as Dependent Variable

Source	SS	df	MS	F
A. Size of Group	1,681.00	1	1,681.00	8.43**
B. Type of Material	252.01	1	252.01	1.26
C. Sequence	332.50	3	110.83	< 1
A × B	284.77	1	284.77	1.43
A × C	839.81	3	279.94	1.40
B × C	1,212.55	3	404.18	2.02
A × B × C	631.67	3	210.56	1.05
Ss/Groups	9,576.62	48	199.51	
Total	14,810.93	63		

**p < .01

sons may be postulated for this result. The first is that the pairs were in some sense working successfully as teams. If the members of a pair had competed in making card choices and one member had ignored the information made available by the other, it would seem likely that pairs would have made more card choices than individuals. This was not the case.

Secondly, it is possible that the members of a typical pair had, between them, a superior memory capacity when compared with the typical individual. Cahill and Hovland (1960) have shown on a concept attainment task that sequentially presented instances lead to poorer performance than simultaneously presented instances. The authors interpreted this result as evidence that memory requirements in the former treatment were greater, and that errors in memory lead to poorer performance. In the concept attainment task used for the present study, the information obtained by Ss from successive selections of instances is accumulated essentially in a sequential manner. If memory is important to this task, it would seem reasonable to assume that pairs would benefit from their greater combined memory capacity. Since the members of a pair were instructed to work as a team and were allowed to communicate freely, they would be able to share accumulated information. The information on a previously selected instance would thus have a better chance of being recalled by one or the other of the members of a pair than by an individual working alone. The latter would have to make more card choices in order to confirm information he was unsure of or to regather forgotten information.

The third possibility is that the pairs had twice the chance of individuals of having a good problem solver as one of the members of the pair. Since no record was kept of which member of the pair made which card choices, this possibility can only be raised and not examined.

Number of Card Choices to the First Hypothesis

The summary of the ANOVA with number of card choices to the first hypothesis as the dependent variable is presented in Table 5. As is indicated in this table, no main effect or interaction was significant. While this variable did not aid in discriminating differences in performance between treatment groups, this knowledge is itself valuable. Card choices to the first hypothesis might be construed to be a measure of "conservatism" of the Ss on the task. Ss performing in a more conservative manner on this task might tend to choose more cards and to reselect cards previously chosen before offering an initial hypothesis. If this is true, then the effects of size of group, type of material, sequence, and the interactions of these effects had no significant influence on this kind of conservative behavior.

Number of Hypotheses Offered

The summary of the ANOVA with number of hypotheses offered as the dependent variable is presented in Table 6. The main effect of sequence was significant at the .01 level. No other main effect or interaction was significant. The mean number of hypotheses offered in the four sequences were (1) 8.62, (2) 9.56, (3) 14.69, and (4) 8.94. It can be observed that Ss in sequence 3 offered notably more hypothe-

TABLE 5

Summary of Analysis of Variance with Card Choices to the First Hypothesis as the Dependent Variable

Source	SS	df	MS	F
A. Size of Group	226.88	1	226.88	1.88
B. Type of Material	242.19	1	242.19	2.01
C. Sequence	69.95	3	23.32	< 1
A × B	358.63	1	358.63	2.98
A × C	102.20	3	34.07	< 1
B × C	602.45	3	200.82	1.67
A × B × C	98.63	3	32.88	< 1
Ss/groups	5,785.31	48	120.53	
Total	7,486.24	63		

TABLE 6

Summary of Analysis of Variance with Number of Hypotheses Offered as Dependent Variable

Source	SS	df	MS	F
A. Size of Group	1.41	1	1.41	< 1
B. Type of Material	.66	1	.66	< 1
C. Sequence	97.45	3	32.48	5.65**
A × B	1.13	1	1.13	< 1
A × C	18.70	3	6.23	1.08
B × C	6.07	3	2.02	< 1
A × B × C	7.98	3	2.66	< 1
Ss/Groups	275.81	48	5.75	
Total	409.21	63		

**p < .01

ses than those in the other three sequences. This is consistent with the finding that Ss in sequence 3 took a longer mean time to criterion than those in the other three sequences. There is, however, no readily available explanation for the significant difference between sequences when performance is measured by number of hypotheses offered.

The mean number of hypotheses offered in each of the four ordinal positions of the concepts is represented in Figure 2. The points indicate that number of hypotheses offered is, to some extent, a measure of the facilitation in performance which occurs as Ss gain practice in attaining concepts. The magnitude of this improvement is rather small, with the difference in the mean number of hypotheses offered on the first and fourth concept being 1.6 hypotheses.

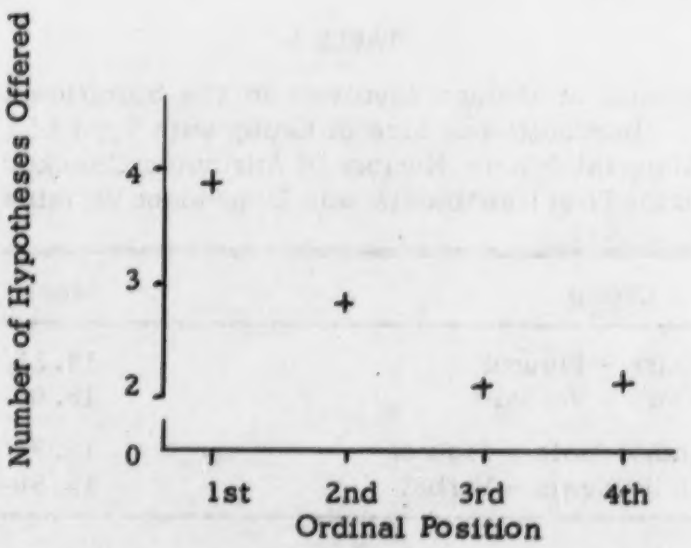

FIG. 2. Number of Hypotheses Offered as a Function of Ordinal Position of the Concept

Number of Attributes Checked to the First Hypothesis

The summary of the ANOVA with number of attributes checked to the first hypothesis is presented in Table 7. None of the main effects was significant. The first order interaction of size of group with type of material was significant at the .01 level. None of the other interactions was significant.

For three of the dependent variables considered previously (time to criterion, total number of card choices, and number of hypotheses offered), increasing values of the variable would appear to be associated with poorer performance. For number of attributes checked, increasing values indicated better performance. Thus from the means of groups involved in the interaction of size of group with type of material (Table 8) it can be observed that pairs and individuals checked about the same number of attributes to the first hypothesis on the verbal material; pairs checked more attributes on the figural material than they did on the verbal material, while individuals checked substantially fewer attributes on the figural material than they did on the verbal material. Apparently the figural material had differential effects on the performance of individuals as opposed to pairs, while on the verbal material no such effects were manifested.

As is indicated in Figure 3, number of attributes checked to the first hypothesis was a function of ordinal position of the problem. The negatively accelerated progression of points again indicates that familiarization and practice with the materials facilitate performance.

TABLE 7

Summary of Analysis of Variance with Number of Attributes Checked to the First Hypothesis as Dependent Variable

Source	SS	df	MS	F
A. Size of Group	8.26	1	8.26	2.61
B. Type of Material	1.89	1	1.89	< 1
C. Sequence	9.78	3	3.26	1.03
A × B	14.06	1	14.06	4.44*
A × C	7.08	3	2.36	< 1
B × C	15.70	3	5.23	1.65
A × B × C	3.03	3	1.01	< 1
Ss/Groups	152.12	48	3.17	
Total	211.92	64		

*$p < .05$

TABLE 8

Means of Groups Involved in the Significant Interaction of Size of Group with Type of Material Where Number of Attributes Checked to the First Hypothesis was Dependent Variable

Group	Mean
Pairs - Figural	19.25
Pairs - Verbal	18.06
Individuals - Figural	15.94
Individuals - Verbal	18.50

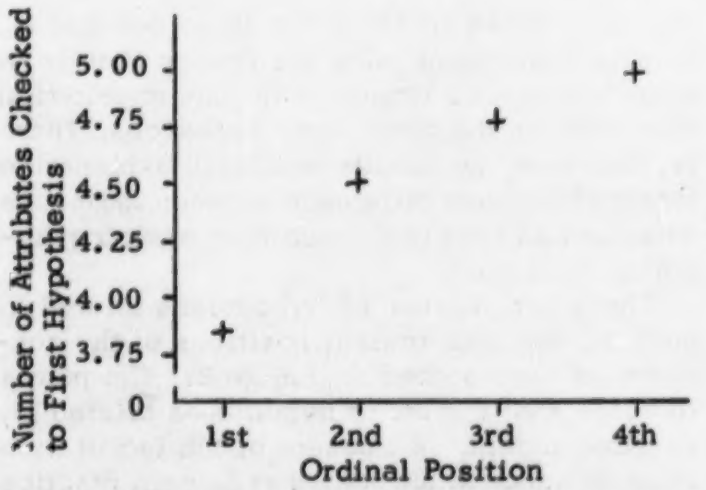

Fig. 3. Number of Attributes Checked to First Hypothesis as a Function of Ordinal Position of the Concept

IV
DISCUSSION

In the previous section, results were presented separately from the analyses of variance computed for each of five dependent variables, and those results which were statistically significant were discussed. To draw conclusions from these analyses it is necessary to consider the effects of the independent variables across the dependent measures.

In comparing the performance of pairs with individuals, it was found that pairs made significantly fewer total card choices than individuals. In addition, pairs performed as well as individuals in terms of the other dependent variables. These findings when considered together indicate a general superiority of pairs over individuals. Pairs were, in effect, performing as well as individuals, and doing so with fewer card choices. A tentative explanation for this result is that the joint memory capacity of members of a pair working as a team was superior to that of individuals. Some experimenters (Faust, 1959; Anderson, 1961) have suggested that the superior performance of groups when compared with individuals is due to the higher probability of having a good problem solver in the group. No attempt was made in the present study to discover whether the performance of a pair was actually determined by the performance of one of its members. This question is one which needs to be dealt with in future research.

In this study it was found that Ss attaining concepts on verbal material took a longer time to criterion than Ss working with figural material. It is interesting to note that the two groups did not differ as to their total number of card choices. Since the Ss on the verbal material took significantly longer time to criterion to make a sequence of card choices to attain a concept than Ss working on the figural material, but did not make significantly more card choices, it would seem reasonable to assume that the former Ss were simply taking a longer time per card choice than were the latter. This would tend to support the suggestion that information on the figural material was more easily gathered than information on the verbal material.

It was illustrated that performance, as measured by time to criterion, number of hypotheses offered, and number of attributes checked to the first hypothesis, was a function of the ordinal position of the problem in the sequence. These findings were consistent with one another; from each it was indicated that performance tended to improve across successive concepts. This improvement would appear to be due to familiarization with the materials and practice on the task. Another factor which may have contributed to the improvement across trials was that all of the concepts used in the experiment had two relevant attributes. As each successive concept was attained, the probability of the Ss' discovering and using this information may have increased. Such information would substantially decrease the number of hypotheses which were tenable and may have tended to increase the Ss' chances of guessing the correct one.

Sequence was a significant factor when performance was measured by time to criterion and number of hypotheses offered. It is possible that this is due to the particular four sequences used, resulting in differential transfer between the problems. Several combinations of transfer effects may have been operating, and any one of these combinations may have resulted in the significant effect of sequence. Further study designed to deal explicitly with sequence effects needs to be done before any one explanation can be considered to account for the effect.

The interaction between size of group and type of material was significant when performance was measured by number of attributes checked to the first hypothesis. In considering this interaction, it was observed that pairs checked more attributes than individuals on the figural material; pairs checked fewer attributes

on the verbal material than they did on the figural material, while individuals checked more on the verbal than on the figural; pairs and individuals checked about the same number of attributes on the verbal material. It would appear that the figural material had differential effects on pairs and individuals while the verbal material did not have such effects.

REFERENCES

Anderson, N. H. Group performance in an anagram task. J. soc. Psychol., 1961, 55, 67-75.

Bruner, J. S., Goodnow, Jacqueline J., & Austin, G. A. A study of thinking. New York: John Wiley, 1956.

Cahill, H. E., & Hovland, C. I. The role of memory in the acquisition of concepts. J. exp. Psychol., 1960, 59, 137-144.

Davidon, R. S. The effects of symbols, shift, and manipulation upon the number of concepts attained. J. exp. Psychol., 1952, 44, 70-79.

Duncan, C. P. Recent research on human problem solving. Psychol. Bull., 1959, 56, 397-429.

Faust, W. L. Group versus individual problem solving. J. abnorm. soc. Psychol., 1959, 59, 68-72.

Heidbreder, Edna. The attainment of concepts: I. Terminology and methodology. J. gen. Psychol., 1946, 35, 191-223.

Klausmeier, H. J., Wiersma, W., & Harris, C. W. Efficiency of initial learning and transfer by individuals, pairs, and quads. J. educ. Psychol., 1963, 54, 160-164.

Restle, F., & Davis, J. H. Success and speed of problem solving by individuals and groups. Psychol. Rev., 1962, 69, 520-536.

Runquist, W. N., & Hutt, Valorie H. Verbal concept learning in high school students with pictorial and verbal representation of stimuli. J. educ. Psychol., 1961, 52, 108-111.

Tuckman, J., & Lorge, I. Individual ability as a determinant of group superiority. Hum. Relat., 1962, 15, 54-61.